Optical System for Monitoring Net Occular Blood Flow, Phase II

Completed Technology Project (2016 - 2022)

Project Introduction

Physical Sciences Inc. (PSI) proposes to develop a novel ophthalmic imaging platform for the characterization and monitoring of visual impairment observed in long-duration space flights. This platform will combine non-invasive measurement of retina/choroid structure and ocular blood flow based on Optical Coherence Tomography (OCT) and wide-field semi-quantitative global flow visualization using Line-scanning Doppler Flowmetry (LSDF). During Phase II a system will be fabricated utilizing the most deeply penetrating waveband around 1060 nm which is especially critical for choroidal imaging. Therefore, the PSI's instrument will address the need for accurate 3D measurement of posterior segment layer thicknesses and volumes, and vascular (retinal and choroidal) topology and flow quantification. This novel imaging platform will enable Phase II imaging studies in animals and human subjects in normal and fluid-shift models of micro-gravity conditions, which are in line with the International Space Station (ISS) mission. Prior PSI experience in developing advanced ophthalmic imaging systems and space-qualified hardware will be leveraged to ensure the successful outcome of this important R&D program.

Anticipated Benefits

This technology addresses a clear need for studying and quantifying image-based ocular biomarkers that can be used to assess the health status of astronauts. As already known, changes in intracranial pressure (ICP) and correlated effects on vision encountered in space exploration missions, collectively referred to as Visual Impairment and Intracranial Pressure (VIIP) syndrome, have created the need for advanced imaging modalities to monitor these effects, pre and post flight, and potentially on board the International Space Station (ISS). Investigations of VIIP phenomena and its potentially permanent effects have elevated it to high priority gap and operational need status. Ocular functional and structural alterations including reduction of near visual acuity, signs of several degrees of optic disc edema, globe flattening with hyperopic shift, choroidal folds and cotton wool spots have been experienced by astronauts involved in long-duration space travels. The etiology of these findings is unknown, however, it has been observed that these anatomical changes affect retinal physiology and may also cause glaucoma-like loss of neurons or retinal degeneration during very long-duration flight such as for a Mars mission. The response to fluid shift with edematous changes in the optic nerve head (ONH), retinal and choroidal vessels and possibly neurons of various types, and nerve fiber bundles may constitute a long-term visual impairment risk.This technology has multiple potential uses in clinical research and healthcare. Understanding normal retinal functions and its alterations is a very active research area. The retina is among the most highly vascularized and metabolically active tissues in the body. It represents the only part of the central nervous system where capillary blood flow is visible and can be measured non-invasively. Like the central

Table of Contents

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Physical Sciences, Inc.

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

Carlos Torrez

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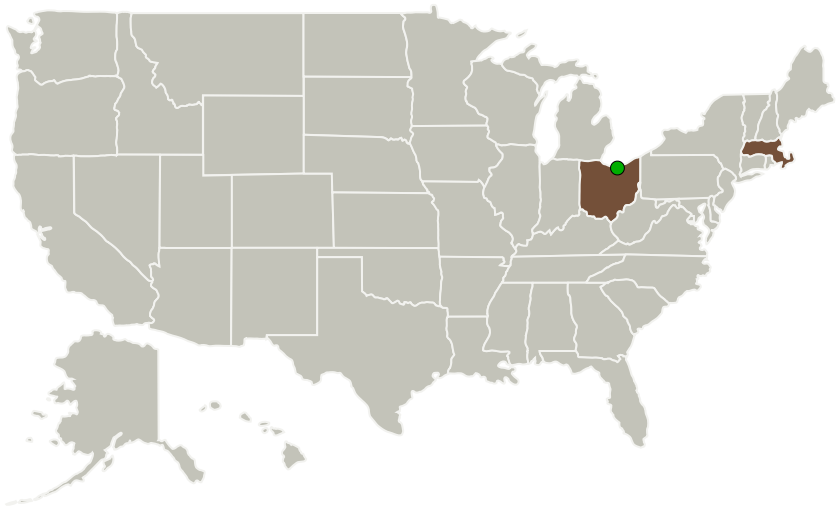
nervous system it is susceptible to ischemic (insufficient blood flow) injury. Degenerative neurovascular diseases (e.g., diabetic retinopathy) of the eye often have either hemodynamic consequences or causes, though the mechanisms are poorly understood. In addition to diseases there are other causes that can disturb the hemodynamic activity of the retina. Little is known about the ocular and cerebral blood flow during exposure to increasingly hypoxic conditions (insufficient oxygen supply) or hypercapnia (too much CO2). Blood flow alterations occur under the influence of prolonged hypoxia. There is a close correlation between the regulation of blood supply to the brain and to the retina, due to similar vascular regulatory processes. The auto-regulation of blood flow in the eye is clearly exquisitely sensitive to many neurovascular and metabolic signaling systems. An advanced diagnostic imaging system which can accurately track multiple anatomical and physiological changes in the eye over time is therefore fundamental to understanding and mitigating these effects.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Physical Sciences, Inc.	Lead Organization	Industry	Andover, Massachusetts
Glenn Research Center(GRC)	Supporting Organization	NASA Center	Cleveland, Ohio

Project Management *(cont.)*

Project Managers:

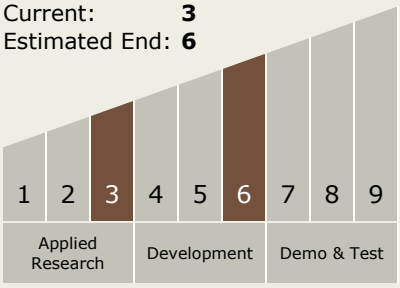
Emily S Nelson
Matthew C Deans

Principal Investigator:

Mircea Mujat

Technology Maturity (TRL)

Start: **3**
Current: **3**
Estimated End: **6**



Target Destinations

The Sun, Earth, The Moon, Mars, Others Inside the Solar System, Outside the Solar System

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Primary U.S. Work Locations	
Massachusetts	Ohio

Project Transitions

May 2016: Project Start

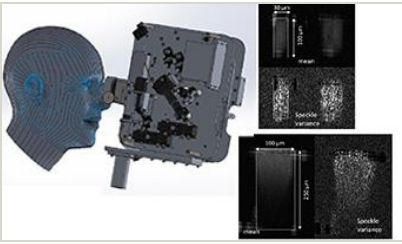
October 2020: Closed out

Closeout Documentation:
- Final Summary Chart*(https://techport.nasa.gov/file/139633)*

September 2022: Closed out

Closeout Documentation:
- Final Summary Chart PDF*(https://techport.nasa.gov/file/139634)*

Images



Final Summary Chart Image
Optical System for Monitoring Net Occular Blood Flow, Phase II
(https://techport.nasa.gov/image/132808)

Briefing Chart Image
Optical System for Monitoring Net Occular Blood Flow, Phase II
(https://techport.nasa.gov/image/131028)